Postdoctoral research associate Todd Linscott evaluates cold hardiness of wheat breeding lines after a simulated freezing test.

Abscisic Acid—The Plant Stress Hormone

Every fall, wheat farmers in the Pacific Northwest gamble their next year's fortunes: They plant their seeds. Then nature rolls the dice. Will it rain enough to support a good crop? Will a sudden freeze kill the plants?

Several scientific discoveries may one day reduce such risks for growers of wheat—and perhaps of other crops as well. For example, researchers have long known that a hormone called abscisic acid (ABA) plays a role in how plants respond to weather stresses, such as cold and drought. ARS plant physiologist Kay Walker-Simmons and chemist Sue Abrams, who's with the National Research Council of Canada, discovered features of the ABA molecule that affect wheat and barley plants.

"ABA slows seed germination and improves wheat's tolerance to cold and drought," says Simmons. "We showed that by chemically altering ABA, we could increase these beneficial activities." Simmons led the ARS Wheat Genetics, Quality, Physiology, and Disease Research Unit in Pullman, Washington, until last October. Now she's ARS' national program leader for grain crops.

Plants normally produce an enzyme that breaks down ABA. When the ABA levels drop low enough, the hormone can no longer inhibit germination, and the seeds sprout. But sometimes the plants would fare better if they delayed germinating. For example, light rains in the Pacific Northwest might trigger wheat to germinate. But if the weather dries up before the more substantial rains begin, the tender seedlings could die. If the seeds waited until more water was

BRIAN PRECHTEL (K9210-2)

Postdoctoral research associate Benjamin Rangel conducts an electrophoresis gel test of candidate genes and DNA markers associated with sprouting resistance and cold hardiness in wheat.

available before sprouting, they would be less likely to suffer from drought.

Abrams modified the part of the ABA molecule that's broken down by the enzyme. Then she and Simmons demonstrated that chemically blocking the enzyme allows ABA to stay active longer. This means that some sort of seed treatment with the altered ABA might provide the extra delay needed to improve wheat survival during drought conditions.

Earlier, the researchers found the parts of the ABA molecule that regulate whether a wheat plant germinates prematurely. "Mature wheat kernels can sprout in the head when it rains just before harvest," Simmons says. Such rains fall about 1 year in 5 in some areas of the Pacific Northwest and with varying frequency worldwide. Farmers can sell the sprouted wheat for animal feed but lose up to half the crop's value. (See "Hormone Snippet to Kernel: Don't Sprout!" *Agricultural Research*, April 1995, p. 23.) Simmons' team also identified an array of genes that appear to partially confer drought and cold hardiness. They hope to use this information to make better plant selections for breeding programs.

"When plants are stressed, these genes respond to the presence of ABA by producing proteins that somehow help the plants better withstand cold or drought," Simmons says. Although the researchers are still unraveling exactly what the genes and their proteins do, they all seem to bind well with water.

The findings may have unique applications. Simmons worked with ARS scientists in Beltsville, Maryland, to show that some of these water-binding proteins could protect turkey sperm during cold storage. She believes the proteins may act as buffers, preventing damage from very rapid hydration or dehydration.

"Our next goal was to discover how ABA signals plants to respond to cold and drought," Simmons says. Her team found a likely trigger: an enzyme known as protein kinase. "Protein kinases are involved in many signaling responses. They can cause rapid changes in the structure and function of other proteins," she says.

Simmons and graduate student Robert Anderberg discovered the first protein kinase involved in plant responses to ABA. She believes that selecting plants that make this kinase faster or in greater abundance may enhance the plants' ability to withstand environmental stress. Her team has cloned the genes that produce the protein kinases, and ARS has applied for a patent on use of the genes. Simmons' team chose to study winter wheat plants because of their importance as a crop and because they tolerate environmental stress better than many other plants. But because ABA is a key hormone in all plants, their findings may be useful for improving other crops, as well.

KEITH WELLER (K9213-2)

Plant physiologist Kay Walker-Simmons examines club wheat heads from the Pacific Northwest for preharvest sprouting damage.

Her group is also contributing to understanding the complete function of the genes in the wheat seed. As part of the wheat genome project, she's supplying tissue samples of dormant and ABA-treated seeds to ARS scientists in Albany, California, for DNA sequencing. The project is funded by the National Science Foundation and involves ARS and 11 universities. The project aims to identify all the genes expressed in wheat seeds and to determine their function.

"I've spent most of my career looking at individual genes," says Simmons. "Now we'll be able to look at hundreds of genes that are expressed when plants are subjected to environmental stress. That's a whole new level of research."—By **Kathryn Barry Stelljes,** ARS.

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